Diversity in Waste Management Methods & Wastes: Why the "Anyway" Concept Should Be Abandoned

EPA should abandon use of the concept "anyway waste" and the implication that such a waste has a biogenic accounting factor (BAF) equal to zero. The concept is confusing because it seemingly confounds an inventory accounting approach for biogenic carbon emissions from a single waste management method with a consequential life cycle analysis (LCA) approach for comparing two different management methods for biogenic wastes. The concept also is fraught with operational and other methodological difficulties and uncertainties.

A better methodology for developing a measurement to use in evaluating carbon emissions from combustion facilities would be to rely on a mass balance accounting approach. This approach would be simple to implement in that the carbon contents of the various biogenic wastes are well known. These transparent emissions calculations then could be used as the basis for the methodologically much more difficult evaluation of determining whether combustion of a given biogenic waste at a combustion facility increases or decreases carbon emissions in comparison to management options likely to be available for that waste over the lifetime of the combustion facility.

Summary of Issues with the Concept "Anyway Waste" and Its Use to Assert that BAF=0

There are a variety of methods available for managing each type of waste generated at any given location and point in time. There may be a typical method in use, but there also are almost always multiple methods available for wastes management, especially when wastes are segregated by type. Both the typical or average management method and the distribution of available methods change over time, often dramatically. Frequently there are more off-site options for managing a waste than are available on the site where that waste is generated. This diversity makes it difficult to determine the typical/base case/ business as usual (BAU) treatment for a given waste at a point in time, let alone over the long lifetime of a combustion facility. As a result there will be substantial uncertainties in calculating "anyway" carbon emissions against which to compare carbon emissions from a combustion facility.

Adding to the complexity is that the carbon profile of any treatment method for a given waste at a particular facility will depend on many specific technological parameters and management practices. For example, the carbon footprint of an anaerobic landfill for a given waste depends on many landfill and waste specific factors, including:

- Carbon content of the waste material,
- Biodegradability of the waste material's carbon under anaerobic conditions,
- Landfill gas capture efficiency over the years until the waste stops generating methane,
- Rate of methane oxidation as uncaptured landfill gases migrate to the landfill's surface,
- Whether the captured landfill gas is flared or used to generate electricity and/or heat,
- The heating efficiency of the technology used to convert methane to energy, and,
- The fuel (renewable, natural gas, petroleum, or coal) displaced by energy generated from landfill methane.

Similarly, a combustion facility's carbon footprint will depend on numerous factors, including:

- Whether the facility generates electricity and/or heat,
- Heating efficiency of the technology,

- Average facility availability versus downtime,
- Moisture content of the waste,
- Carbon content of the waste, and,
- Type of fuel displaced.

Given complexities in calculating carbon footprints, uncertainties regarding what the BAU treatment or treatments would otherwise be during the lifetime of the combustion facility if it did not exist, and uncertainties regarding the mix of wastes to be processed during the combustion facility's lifetime, it seems very speculative to assume that a combustion facility's BAF should be set at zero simply because its waste feedstocks have been deemed "anyway" wastes.

Another issue is that the concept of "anyway" wastes and the assertion that these wastes should have BAF=0 confuses and confounds two different reasons for computing carbon footprints. In life cycle analysis (LCA) these two objectives are sometimes indicated by noting whether the analysis is an attributional or consequential LCA. The objective of the former type LCA in evaluating climate impacts is to profile and inventory the carbon emissions of an existing activity – what might be termed a "what is" analysis. The objective of the latter type LCA is to compare carbon emissions of a proposed activity against emissions of the existing activity that will be replaced – what might be termed a "what if" analysis.[1]

An additional concern is that setting BAF = 0 for a facility that combusts a particular type of waste may be viewed as implying that the carbon emissions of the combustion facility are zero, and/or that carbon emissions will go down as a result of replacing the BAU management method(s) with the proposed combustion method. This misunderstanding could be used to incentivize combustion to the detriment of other wastes management methods. In the unlikely event that carbon footprints of the BAU and combustion methods are actually equal, then total carbon emissions will not change. More likely carbon emissions will go up or down over the combustion facility's lifetime, depending on a host of technological and management practices used for BAU methods compared with the combustion method.

The remainder of this essay provides examples for solid wastes, forestry wastes and mill wastes that illustrate the oversimplifications in terming a biogenic waste as "anyway" and assuming that a combustion facility handling the "anyway" waste should be deemed to have BAF=0.

Municipal Solid Waste (MSW) Materials

Thirty years ago most product and packaging materials in municipal solid waste (MSW) were discarded in garbage or trash and sent to landfills or incinerators, most of which did not even recover energy. Numerous communities now have recycling rates for many materials that are greater than 50%. For example, Seattle (WA) had newspaper, cardboard and mixed paper recycling rates of 94%, 86% and 75%, respectively, in 2010. Seattle households and businesses also recycled other biogenic materials at high levels – yard debris at 96% and food scraps at 49%, for example. Food scraps are lower than the others because that material's recycling program was instituted only a couple of years ago.

---

[1] Some confusion could be alleviated by not using the word "accounting" when describing a conceptual what-if measurement such as BAF. Perhaps biomass what-if factor (BWIF) would better indicate that this factor compares carbon profiles for two different waste management methods.

Seattle attained these high recycling rates by a carefully sequenced series of price signals, regulatory mandates and education and outreach activities over the past 25 years. Clearly, in Seattle the anyway or base case or BAU for these biogenic materials has changed from landfill to recycling over a rather short period of time. Figure 1 illustrates Seattle's progress at reducing disposal of residential MSW disposal.

Continual improvement in recycling rates means that materials that were thrown away at one point in time are eventually recycled at a later point in time. It's well established that recycling has a lower life-cycle carbon footprint than either burying or burning, regardless of whether energy recovery accompanies the burying or burning.[2] Hence, the calculation of the offset or "anyway" treatment against which to measure the carbon footprint of combustion changes dramatically as materials move from MSW disposal streams to recovery via recycling.

This gradual shift towards materials recycling over time can be inhibited by recycling disincentives that may accompany a community's use of combustion for MSW disposal. Examples of these disincentives in a community's contractual commitments for MSW disposal at a combustion facility include annual disposal tonnage requirements, annual power generation requirements, and fixed payments for facility capital costs. Another recycling disincentive can occur via subsidies in the form of higher than market payments for energy, whether power or heat or both, generated from combustion of MSW materials. Assigning a BAF = 0 to combustion of MSW materials could be seen as a signal that such subsidies are proper or even required.

Figure 1
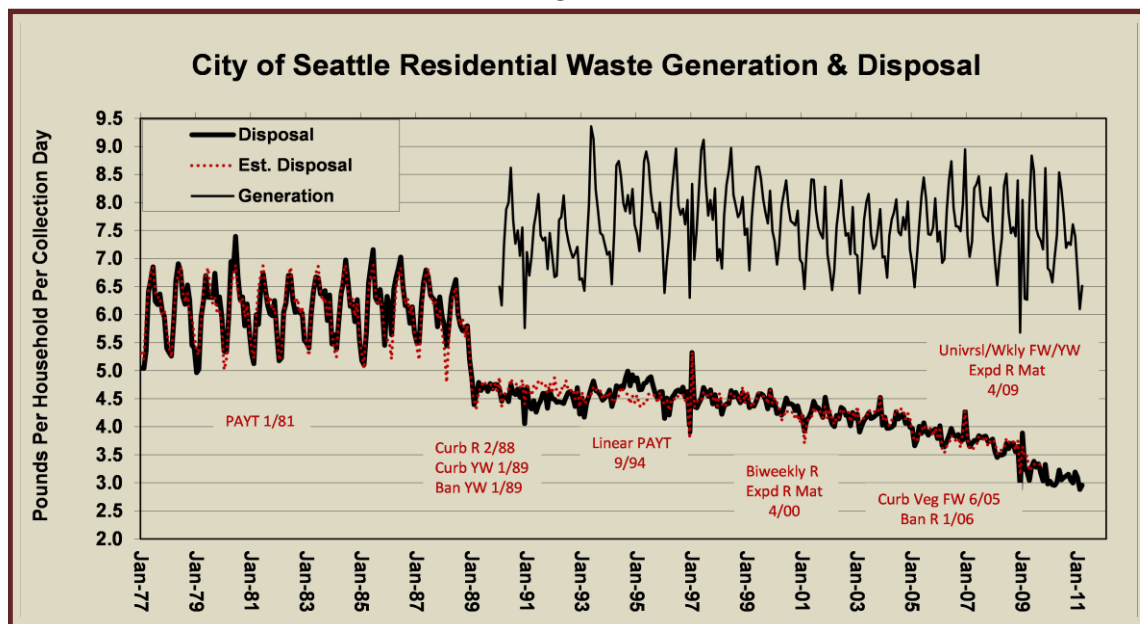
The paper Morris and Matthews (2010) describes development of a consumption-based GHG and other pollutants measurement index – the Consumer Environmental Index (CEI) -- for the Washington State Department of Ecology. The CEI includes all life cycle phases of consumption – resource extraction, manufacturing, transportation, use, and end-of-life management for wastes. One of the surprising results of the study was that an

---

[2] See, for example, Denison (1996), Morris (2005) and Morris (2008). The energy conservation benefits of recycling compared with energy generation from combustion are summarized for a wide variety of materials in Morris (1996).

average household recycling all conventional curbside recyclable waste materials, yard debris and food scraps generated at home or at work reduces carbon emissions as much as cutting their gasoline and diesel fuel purchases by 40%. This result emphasizes the importance of not tilting end-of-life management choices for packaging materials and products toward combustion through perverse incentives that favor disposal of wastes into the garbage stream over recycling.

Burying Versus Burning MSW Materials

Even when burying is the waste management method from which a combustion facility pulls its biogenic inputs, there is uncertainty as to the relative carbon footprints of burning versus burying that will render BAF = 0 erroneous. Clean (i.e., untreated and unpainted) urban wood waste is a major biogenic component of solid waste streams and provides an example of this uncertainty.

The life-cycle policy analysis article Morris (2010) established a graphical depiction of the relationship between the carbon footprints of burning and burying mixed MSW as a function of the landfill's capture rate for methane. Figure 2 depicts that graphical relationship for just wood wastes. For landfill gas (LFG) capture rates associated on the graph with positive values for the net difference in carbon emissions between burning and burying, burning is better for the climate than burying wood wastes. For capture rates associated with a negative net difference in carbon emissions, burying is better.

The time frame for the comparison shown in Figure 2 is 100 years. The graph assumes that energy from waste provides power that displaces natural gas-fired electricity. The low and high precipitation lines indicate the lower rate of methane generation at landfills located in an area with low versus high precipitation levels. Precipitation is often thought to enhance the rate of biodegradation in an anaerobic landfill.

Figure 2
Wood Waste Carbon Emissions for Landfill Gas to Energy minus Combustion Waste-to-Energy
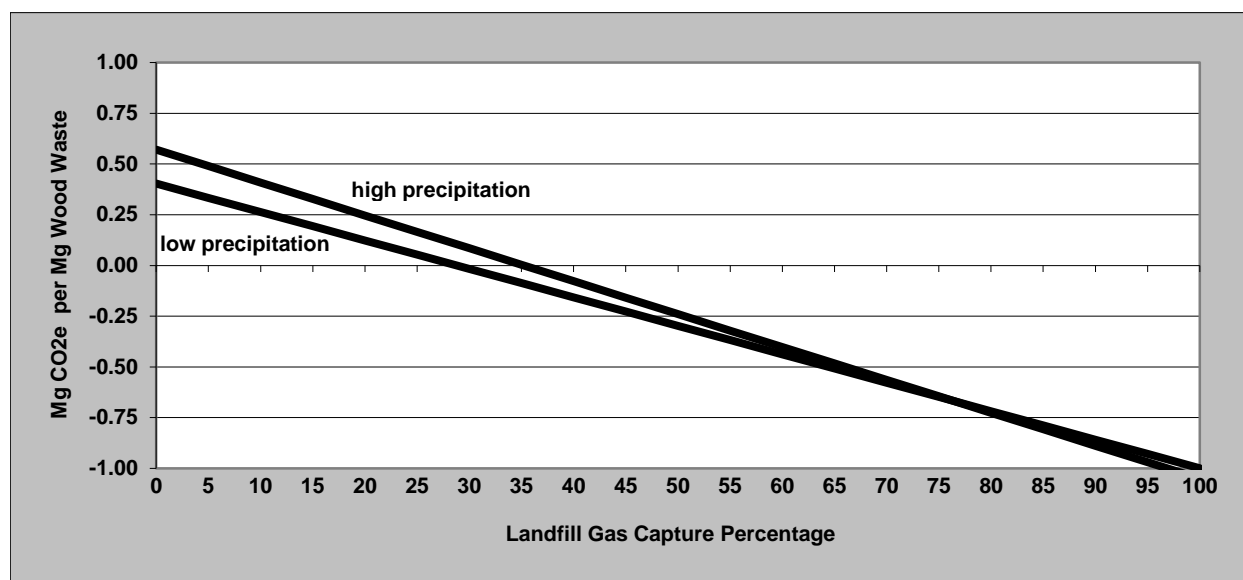
As indicated with Figure 2, for LFG capture rates above 35% landfilling wood wastes has a lower carbon footprint than combustion of woody biomass. If the offset power is coal-fired, LFG capture rates need to be above 50% for the landfill carbon footprint to be lower than combustion's footprint. If the offset power is nearly carbon neutral

then this breakeven LFG capture rate falls below 10%. If energy from waste generates combined heat and power at an 80% efficiency rate, breakeven LFG capture rates increase by about 35 percentage points.

The low breakeven LFG capture rates for landfilling wood wastes are in large part due to the amount of carbon in wood that does not biodegrade to methane in an anaerobic landfill. Over 80% of the carbon in wood wastes remains intact and stored in an MSW landfill. Landfill carbon biodegradation and storage rates for various MSW materials have been well researched by Professor Morton Barlaz and his colleagues at North Carolina State University[3].

As a contrast to Figure 2, Figure 3 shows the same breakeven analysis for food scraps. Food scraps are at the opposite end from wood on the spectrum for biodegradation performance of biogenic materials in an anaerobic landfill. Less than 15% of the carbon in food wastes remains stored in an anaerobic landfill. As a result the baseline breakeven landfill gas capture efficiency required for a landfill to outperform combustion in terms of carbon emissions is much higher. As indicated on the graph a landfill needs to capture about 85% of generated methane to perform as well as combustion, even though food waste generates little, and perhaps no, net energy when burned.

These two examples illustrate the diversity of carbon footprints for different wastes for just two management methods.

Figure 3
Food Waste Carbon Emissions for Landfill Gas to Energy minus Combustion Waste-to-Energy

---
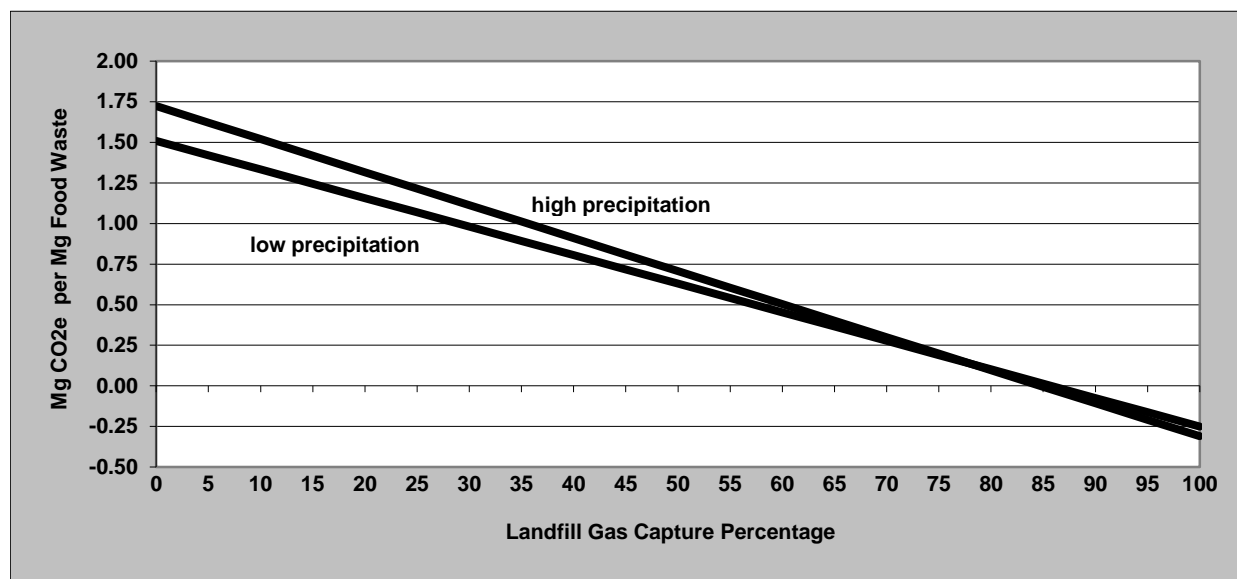
[3] For example, see Eleazer *et al* (1997) or Barlaz (1998). Biodegradation and carbon storage for various types of wood wastes are assessed in Wang *et* al (2011). Based on De la Cruz and Barlaz (2010) the low precipitation line in Figure 2 likely represents wood waste biodegradation rates in MSW landfills regardless of precipitation levels where the landfill is located.

Forestry Residues

Just as MSW BAU has and continues to change rapidly from disposal to reuse, recycling, composting and digestion, the methods for managing forestry wastes or residues will change dramatically if forestry residues begin to be transported out of the forest for treatment off site. Management methods that will be available at off-site facilities include recycling, composting and even landfill disposal in addition to combustion. The comparative carbon footprints for management of forestry residues off site resemble those footprints for clean urban wood wastes. Hence, carbon footprint factors for forestry residues should be set with the same objectives in mind as for biogenic MSW materials. That is, avoidance of perverse incentives, enabling of progress over time toward using management options with lower carbon footprints, and recognition of the complex parameters and facility management choices that determine carbon emissions for a particular treatment at a particular location and time.

Mill Wastes

Mill wastes can also be managed using many of the management methods available for clean urban wood wastes and off-site available forestry residues. In this case, as well as in the case of forestry residues, incentivizing combustion through regulatory and economic means could come at the expense of available recycling opportunities. Engineered wood product manufacturers are especially concerned about incentives for combustion that could increase prices wood products manufaturers pay for mill and forestry wastes, and/or decrease availability of those waste materials.[4]

References

Barlaz M A (1998): Carbon Storage during biodegradation of municipal solid waste components in laboratory-scale landfills. *Global Biogeochemical Cycles* 12(2) 373–380 (abstract available at http://www.agu.org/pubs/crossref/1998/98GB00350.shtml)

Carbon River Sustainable Commerce Systems: An Analysis of carbon emissions for different end of life scenarios for virgin, recycled and low grade wood fibre. Prepared for Wood Panel Industries Federation, Grantham, Lincolnshire, England, May 2010

De la Cruz F B, Barlaz M A (2010): Estimation of Waste-Component Specific Landfill Decay Rates Using Laboratory-Scale Decomposition Data. *Environmental Science & Technology* 44 4722-4728 (abstract available at http://pubs.acs.org/doi/abs/10.1021/es100240r)

Denison RA (1996): Environmental Life-Cycle Comparisons of Recycling, Landfilling, and Incineration: A Review of Recent Studies. *Annual Review of Energy and the Environment* 21 199-237 (abstract available at http://www.annualreviews.org/doi/abs/10.1146/annurev.energy.21.1.191)

Releaser W E, Dole W S, Wang Y-S and Barlaz M A(1997): Biodegradability of Municipal Solid Waste Components in Laboratory-Scale Landfills. *Environmental Science & Technology* 31(3) 911-917 (abstract available at http://pubs.acs.org/doi/abs/10.1021/es9606788)

Morris J (2010): Bury or Burn North American MSW? LCAs Provide Answers for Climate Impacts & Carbon Neutral Power Potential. *Environmental Science & Technology* 44(20) 7944-7949 (abstract available at http://pubs.acs.org/doi/abs/10.1021/es100529f)

---

[4] See Carbon River Sustainable Commerce Systems (2010).

Morris J, Matthews H S (2010): Development of a Consumer Environmental Index and results for Washington State consumers. *Journal of Industrial Ecology* 14(3) 399-421 (abstract available at http://dx.doi.org/10.1111/j.1530-9290.2010.00246.x)

Morris J, Bagby J (2008): Measuring Environmental Value for Natural Lawn and Garden Care Practices. *International Journal of Life Cycle Assessment* 13(3) 226-234. (abstract available at: http://dx.doi.org/10.1065/lca2007.07.350**)**

Morris J (2005): Comparative LCAs for Curbside Recycling Versus Either Landfilling or Incineration with Energy Recovery. *International Journal of Life Cycle Assessment* 10(4) 273-284 (abstract available at http://dx.doi.org/10.1065/lca2004.09.180.10)

Morris J (1996): Recycling versus incineration: an energy conservation analysis. *Journal of Hazardous Materials* 47(1-3) 277-293 (abstract available at http://dx.doi.org/10.1016/0304-3894(95)00116-6)

Wang X, Padgett J M, De la Cruz F B, and Barlaz M A (2011): Wood Biodegradation in Laboratory-Scale Landfills. *Environmental Science & Technology* 45(16) 6864-6871 (abstract available at http://pubs.acs.org/doi/abs/10.1021/es201241g)